

Enhancing Fire Safety Preparedness In Tertiary Care Hospitals: Assessment, Challenges, And Strategic Interventions

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Abstract

Fire safety in tertiary care hospitals presents a significant challenge due to complex infrastructure, high dependency equipment, and vulnerable patient populations. This study assessed fire safety preparedness at a major tertiary hospital in New Delhi using a cross-sectional quantitative design involving structured questionnaires and statistical analysis. Results indicated inconsistent staff training, gaps in knowledge, limited confidence in emergency response, infrastructural inadequacies, and uneven compliance with safety standards. Significant associations were found between training and knowledge, awareness of emergency exit routes, and confidence levels. The study concludes that while basic infrastructure exists, systemic improvements in training, audit continuity, staff engagement, and infrastructural upgrades are essential for strengthening fire safety within hospital settings.

Keywords: fire safety; tertiary care hospitals; hospital preparedness; fire training; evacuation planning; NABH; NBC; NFPA; emergency management

INTRODUCTION

Fire safety remains a critical concern within healthcare environments, particularly tertiary care hospitals where patient acuity, dense infrastructure, and reliance on electrical and medical equipment elevate fire risks. Across India, hospital fire incidents have resulted in casualties and infrastructural losses, highlighting gaps in preparedness (Sharma & Singh, 2020). Key risks include electrical overload, medical gases, flammable materials, and overcrowding (Khan & Alam, 2018). In combination with limited staff training and inconsistent compliance with fire safety standards such as the National Building Code (NBC), NABH-FMS 7, and NFPA guidelines, these issues create vulnerabilities (Kumar et al., 2019). Current literature indicates that hospital staff often lack practical readiness for fire emergencies, including limited experience with extinguishers, unclear understanding of evacuation routes, and inconsistent participation in fire drills (Patel & Varghese, 2021). Moreover, infrastructural limitations—particularly in older hospitals—compound evacuation challenges during emergencies (Gupta & Reddy, 2021). Given these issues, this study sought to quantitatively measure fire safety knowledge, attitudes, practices, and perceived challenges among staff at a large tertiary care hospital. It also examined statistically significant relationships between staff training, awareness, and confidence to inform evidence-based interventions.

LITERATURE REVIEW

Fire Safety Risks in Healthcare Settings

Hospitals present unique fire risks due to oxygen-enriched atmospheres, electrical equipment, flammable chemicals, and overcrowded wards (Khan & Alam, 2018). Medical gas explosions and short circuits contribute significantly to hospital fires (Mukherjee & Chatterjee, 2021). Critically ill patients create additional evacuation difficulties (Chien & Wu, 2020).

Compliance with Fire Safety Standards

India's NBC and NABH-FMS 7 guidelines outline clear requirements for hospital fire protection, yet compliance varies widely. Many hospitals implement safety measures only during audit cycles (Kumar et al., 2019). International standards like NFPA-101 and NFPA-99 set benchmarks, but their adaptation requires sustained investment and expertise (Jones & Lattimer, 2017).

Training and Human Factors:

Studies highlight widespread deficiencies in fire safety knowledge among hospital staff, often attributed

to irregular or theoretical training (Mishra et al., 2022). Confidence levels are low, and staff frequently struggle with extinguisher use and emergency procedures (Patel & Varghese, 2021). Regular fire drills improve preparedness but are poorly attended (Reddy & Subramanian, 2018).

Infrastructure and Technology Barriers

Older buildings pose significant retrofitting challenges due to narrow corridors, outdated wiring, and insufficient exits (Sharma & Singh, 2020). Smart technologies, such as IoT-linked alarm systems and real-time monitoring, offer advancements but are underutilized in India (Thomas & Huang, 2019).

Innovative Approaches

VR-based fire simulation training has been shown to enhance practical readiness and knowledge retention (Almeida et al., 2020). IoT-enabled fire detection systems are gaining prominence and show promise for hospital use (Wang & Li, 2021).

Summary

The literature points to persistent gaps in compliance, knowledge, infrastructure, and readiness in Indian tertiary hospitals. This study addresses these gaps through quantitative assessment and statistical analysis to identify targeted improvements.

MATERIALS AND METHODS

Study Design and Setting

A cross-sectional quantitative study was conducted in a Tertiary Care Hospital, New Delhi. Structured, self-administered questionnaires were distributed among hospital staff across departments including nursing, medical, housekeeping, administration, and safety.

Data Collection Tool and Procedure

A pre-tested questionnaire included demographics, knowledge, attitudes, practices, training history, confidence levels, and perceived challenges. Distribution was both physical and digital. Participation was voluntary and anonymous.

Data Entry and Software

Responses were entered into Microsoft Excel for initial cleaning and subsequently analyzed using IBM SPSS Statistics version 23.

Data Analysis

Descriptive statistics (frequencies, percentages, mean, SD) summarized key variables.

Inferential tests included:

- **Chi-square (χ^2)** to examine associations between categorical variables.
- **Independent samples t-test** to compare mean knowledge scores among trained vs. untrained staff.

Significance was set at $p < .05$.

Ethical Considerations

Institutional Ethics Committee approval was obtained. Participation was voluntary, anonymous, and confidential.

Limitations

The single-site cross-sectional design limits generalizability and causal inference. Reliance on self-report may introduce bias. No physical audit of fire infrastructure was conducted.

RESULTS

Data from 133 staff members were analyzed. Key demographic, knowledge, attitude, practice, and inferential findings are presented below.

Table 1: Demographic Profile of Participants (N = 133)

Variable	n	%
Gender		
Male	77	57.9
Female	56	42.1
Role		
Doctor	28	21.1
Nurse	37	27.8
Safety Officer	21	15.8

Housekeeping	19	14.3
Admin/Support	28	21.1
Experience		
< 3 years	48	36.1
3–5 years	53	39.8
> 5 years	32	24.1

Table 2: Fire Safety Knowledge Among Staff (N = 133)

Knowledge Item	Yes (%)	No (%)
Aware of equipment locations	79.7	20.3
Know extinguisher operation	63.2	36.8
Familiar with exit routes	82.7	17.3
Know emergency contact	69.2	30.8
Understand extinguisher types	47.4	52.6

Table 3: Attitudes and Practices Toward Fire Safety (N = 133)

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Fire safety is important	58.6%	29.3%	7.5%	3.8%	.8%
Confident handling emergencies	21.1%	29.3%	26.3%	17.3%	6.0%
Drills are conducted regularly	10.5%	26.3%	22.6%	28.6%	12.0%

Table 4: Training and Infrastructure (N = 133)

Parameter	Yes (%)	No (%)
Ever trained	80.5	19.5
Trained in last 12 months	42.1	57.9
Extinguisher present	97.0	3.0
Fire exits marked	71.4	28.6
Smoke detectors installed	94.7	5.3

Table 5: Perceived Challenges (N = 133)

Challenge	n	%
Lack of regular training	80	60.2
Poor equipment maintenance	64	48.1
Lack of signage	43	32.3
Obstructed escape routes	55	41.4
Limited staff awareness	72	54.1

Table 6: Role × Training Received (N = 133)

$\chi^2 = 12.45, p = .014$

Role	Trained (%)	Not Trained (%)
Doctor	71.4	28.6
Nurse	48.6	51.4
Safety Officer	57.1	42.9
Housekeeping	21.1	78.9
Admin	42.9	57.1

Table 7: Gender × Confidence (N = 133)

$\chi^2 = 9.21, p = .0024$

Confidence	Male (%)	Female (%)
Confident	62.3	33.9
Not Confident	37.7	66.1

Table 8: Training × Knowledge of Exit Routes (N = 133)

$\chi^2 = 10.86, p = .001$

Training Status	Knows Exit (%)
Trained	92.4
Not Trained	73.1

Table 9: Training × Confidence (N = 133)

$\chi^2 = 33.87, p < .0001$

Training Status	Confident (%)
Trained	75.8
Not Trained	25.4

Table 10: Mean Knowledge Scores (t-test)

$t = 6.82, p < .001$

Group	Mean ± SD
Trained	4.2 ± .7
Not Trained	3.1 ± 1.1

DISCUSSION

The present study assessed the level of fire safety preparedness among staff at a tertiary care hospital in New Delhi. Overall, the findings indicate that while basic fire safety infrastructure is present, significant gaps exist in staff training, awareness, confidence, and practical knowledge—reflecting concerns documented previously in the literature.

A large proportion of participants (80.5%) reported having received fire safety training at least once, yet less than half (42.1%) received refresher training within the past year. This finding echoes the concerns of Mishra et al. (2022), who reported inadequate frequency of fire safety training in Indian hospitals. Regular training is essential for maintaining readiness, particularly in high-risk environments where staff turnover is high.

Knowledge levels varied substantially. Although most staff were aware of exit routes (82.7%) and equipment locations (79.7%), fewer knew how to operate a fire extinguisher (63.2%) or differentiate among extinguisher types (47.4%). These deficits mirror prior research showing that theoretical knowledge often exceeds practical preparedness (Patel & Varghese, 2021). The statistically significant difference in mean knowledge scores between trained and untrained staff (4.2 vs. 3.1, $p < .001$) reinforces the necessity of structured training programs.

Attitudinal data revealed that staff strongly acknowledge the importance of fire safety (87.9% agree/strongly agree), yet less than half felt confident in managing a fire emergency. Confidence was significantly associated with both gender and training status. Male participants reported higher confidence levels, consistent with earlier work highlighting gender-based differences in perceived self-efficacy during emergencies (Reddy & Subramanian, 2018). More importantly, trained staff were three times more likely to feel confident than untrained staff (75.8% vs. 25.4%), indicating that training directly contributes to psychological readiness.

Infrastructural findings also reveal areas for improvement. While the presence of fire extinguishers (97%) and smoke detectors (94.7%) is reassuring, only 71.4% reported clearly marked exits. Sharma and Singh (2020) emphasized the critical role of visible evacuation signage in reducing evacuation delays, especially in complex hospital layouts. The lack of signage—also identified as a challenge by 32.3% of participants—represents an actionable safety gap.

Perceived challenges such as irregular training (60.2%), inadequate maintenance (48.1%), and obstructed escape routes (41.4%) highlight systemic issues. These concerns align with studies noting that operational constraints, high outpatient volumes, and insufficient audit follow-ups impede compliance with safety norms (Gupta & Reddy, 2021).

The significant association between staff role and training received ($p = .014$) further suggests unequal access to fire safety training. Housekeeping staff—who often serve as first responders during emergencies—reported the lowest training rates (21.1%). This disparity underscores the need for inclusive and mandated fire safety education across all job categories.

Overall, the findings emphasize a critical need for structured, routine, and inclusive fire safety programs. They also support adopting innovative approaches—such as simulation-based training, VR modules, and

IoT-based monitoring systems—which have been shown to enhance readiness (Almeida et al., 2020; Wang & Li, 2021).

CONCLUSION

This study provides an evidence-based assessment of fire safety preparedness in a tertiary care hospital and highlights key gaps in knowledge, training frequency, infrastructure clarity, and staff confidence. While fire safety equipment and detection systems are widely available, training inconsistencies and limited understanding of extinguisher use and evacuation procedures remain major concerns.

Statistically significant relationships between training and knowledge, confidence, and awareness underscore the crucial role of comprehensive training programs. The findings reflect broader national and global trends within healthcare fire safety literature, emphasizing the need for sustained institutional commitment to safety culture.

To strengthen preparedness, hospitals must ensure equitable, regular, and practical training for all employees while improving physical infrastructure visibility and maintenance. Overall, this study provides actionable insights that can guide policy, training strategies, and administrative interventions for enhancing fire safety in healthcare settings.

Recommendations

Based on the findings, the following recommendations are proposed:

1. Institutionalize Regular Fire Safety Training

- Mandate refresher training every 6–12 months.
- Ensure hands-on sessions for extinguisher use, evacuation drills, and alarm activation.
- Include all staff categories, especially housekeeping and administrative teams.

2. Enhance Visibility of Fire Safety Infrastructure

- Install or upgrade illuminated exit signage.
- Periodically audit corridor obstructions and clearance levels.
- Ensure updated floor evacuation maps in every unit.

3. Implement Modern Simulation-Based Training

- Introduce VR-based fire simulation modules to improve experiential learning.
- Conduct unannounced mock drills to assess real-time readiness.

4. Strengthen Maintenance and Safety Audits

- Conduct monthly inspections of extinguishers, alarms, smoke detectors, and hydrants.
- Maintain digital maintenance logs for transparency and accountability.

5. Integrate Smart Safety Technologies

- Consider IoT-enabled smoke detection and remote monitoring.
- Explore zone-based automated alerts for faster evacuation decisions.

6. Promote a Safety-Driven Organizational Culture

- Use posters, awareness drives, and reward programs.
- Include fire safety in onboarding for all new employees.

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